

CLAIMS

What is claimed is:

1. A negative electrode comprising:
a substrate; and
a coating on said substrate comprising:
a carbonaceous material comprising a mixture of massive ball-shaped graphite particles,
carbon fibers, and graphite flakes; and
a binder.
2. The negative electrode of claim 1 wherein said carbonaceous material comprises a mixture of 10-90% massive ball-shaped graphite particles, 7.5-80% carbon fibers, and 2.5-30% graphite flakes by weight.
3. The negative electrode of claim 1 wherein said carbonaceous material comprises a mixture of 10-80% massive ball-shaped graphite particles, 15-80% carbon fibers, and 2.5-30% graphite flakes by weight.
4. The negative electrode of claim 1 wherein said carbonaceous material comprises a mixture of approximately 80% massive ball-shaped graphite particles, 15% carbon fibers, and 5% graphite flakes by weight.
5. The negative electrode of claim 1 wherein said massive ball-shaped graphite particles, carbon fibers, and graphite flakes have an average particle size of 10-35 μm .
6. The negative electrode of claim 1 wherein said binder is water-based.
7. The negative electrode of claim 1 wherein said binder does not contain fluorine.
8. The negative electrode of claim 1 wherein said binder comprises carboxymethyl cellulose.

9. The negative electrode of claim 8 wherein said binder additionally comprises styrene butadiene rubber.
10. The negative electrode of claim 9 wherein said styrene butadiene comprises 0-5% of the total weight of binder plus carbonaceous material.
11. The negative electrode of claim 9 wherein said substrate comprises titanium.
12. The negative electrode of claim 8 wherein said carboxymethyl cellulose comprises 0-10% of the total weight of binder plus carbonaceous material.
13. The negative electrode of claim 1 wherein said substrate comprises titanium.
14. A battery comprising:
 - a case;
 - an electrode assembly housed in said case and comprising:
 - a negative electrode comprising:
 - a negative substrate; and
 - a negative coating on said negative substrate comprising:
 - a carbonaceous material comprising a mixture of massive ball-shaped graphite particles, carbon fibers, and graphite flakes; and
 - a first binder;
 - a positive electrode comprising:
 - a positive substrate; and
 - a positive coating on said positive substrate comprising:
 - a lithium metal oxide; and
 - a second binder;
 - a separator between said negative and positive electrodes;
 - an electrolyte.

15. The battery of claim 14 wherein said carbonaceous material comprises a mixture of 10-90% massive ball-shaped graphite particles, 7.5-80% carbon fibers, and 2.5-30% graphite flakes by weight.
16. The battery of claim 14 wherein said carbonaceous material comprises a mixture of 10-80% massive ball-shaped graphite particles, 15-80% carbon fibers, and 2.5-30% graphite flakes by weight.
17. The battery of claim 14 wherein said carbonaceous material comprises a mixture of approximately 80% massive ball-shaped graphite particles, 15% carbon fibers, and 5% graphite flakes by weight.
18. The battery as in claim 14 wherein said case is hermetically sealed.
19. The battery as in claim 14 wherein said first binder is water-based.
20. The battery as in claim 14 wherein said first binder contains no fluorine.
21. The battery as in claim 14 wherein said first binder comprises carboxymethyl cellulose.
22. The battery as in claim 21 wherein said first binder further comprises styrene butadiene rubber.
23. The battery as in claim 22 wherein said negative substrate comprises titanium.
24. The battery as in claim 14 wherein said negative coating has a porosity of 20-45%.
25. The battery as in claim 14 wherein said positive coating has a porosity of 20-40%.
26. The battery as in claim 14 wherein said negative electrode forms C_6Li_n , and at a maximum state of charge, $0.5 \leq n \leq 0.9$.

27. The battery as in claim 14 wherein said positive electrode forms $\text{Li}_{1-p}\text{MO}_2$, wherein M comprises one or more transition metals, and at a maximum state of charge, $0.6 \leq p \leq 0.8$.
28. The battery as in claim 14 wherein said negative substrate comprises titanium.
29. The battery as in claim 28 wherein said electrolyte comprises a lithium salt in a cyclic and linear solvent.
30. A method for making a negative electrode comprising the steps of:
providing a substrate;
combining massive ball-shaped graphite particles, carbon fibers, graphite flakes, and a binder in a solvent;
mixing to form a slurry;
coating at least a portion of said substrate with said slurry; and
evaporating said solvent.
31. The method of claim 30 wherein said substrate comprises titanium.
32. The method of claim 30 wherein said solvent is water.
33. The method of claim 30 wherein said binder contains no fluorine.
34. The method of claim 30 wherein said binder comprises carboxymethyl cellulose.
35. The method of claim 34 wherein said binder further comprises styrene butadiene.
36. The method of claim 35 wherein said substrate comprises titanium.